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AUTOMATIZATION OF TECHNOLOGICAL PROCESSES IN FERROUS METALLURGY

A. B. Chelyustkin, Engr
B. A. Levitanskiy, Engr

(From Reports of the First All-Union Conference of Power Engineers of the Metallurgical Industry)

As far back as the First Five-Year Plan, the automatic electric drive was used in metallurgy. A good example of the advantages of automatic control is the complex automatization /full automatic control/ of a semicontinuous rolling mill of the Magnitogorsk Metallurgical Combine, where output increased by 15%, quality improved, and a saving of 1,400,000 kw-hr of electric power was realized in one year. This furnishes a convincing rebuttal of the opinion widespread in the US /?/ that complex automatization is inadvisable since it entails a higher degree of skill on the part of the operators.

Soviet engineers are now confronted with the task of introducing complex automatic control on other mills. But the following points must be taken into account:

1. The unit must be fully mechanized, and the electric drive of all auxiliary mechanisms must have push-button control.

2. Production bottlenecks in individual mechanisms must be eliminated.

3. The personal factor has considerable influence on the output of the unit, and manual control is an obstacle to increased output.

4. With increased output of the unit it is possible to attain uninterrupted production only by providing a continuous supply of ingots or billets.

Under these conditions the plant blooming and billet mills should first be made automatic, if their output limits the work of the subsequent mills.

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Complex automatization of rolling mills involves some new, special apparatus not yet produced by industry. The absence of series production of this apparatus and the fact that it has to be made individually is a serious obstacle to automatization. Such apparatus includes the following:

1. Time Relays With a Large and Remotely Controllable Time Delay

Existing electromagnetic time relays used in automatic electric drive circuits have a maximum time delay of 5 sec, and the delay is altered by adjusting the tension of a spring on the relay itself.

In complex automatic systems the necessary time delays are in many cases determined by the duration of a whole cycle of technological operations and are as high as 30-40 sec and more. It is sometimes necessary to alter this time delay when the shape being rolled changes. In some cases the time delay must be altered due to deviations in the technological regime, e.g., changes in heat or cross section of the billet. It is very important that the operator watching the machinery from his control post should be able to vary the time delay at will without interrupting the work of the mill. This is not possible with the usual electromagnetic time relays.

Electronic time relays were made for this purpose when automatizing the mills of the Magnitogorsk Metallurgical Combine. However, their design and circuit needed further modifications. For this reason, the Central Automatics Laboratory developed original designs of electronic time relays fitted with attachments for remote control of the time delay. Production of these relays is now being organized.

2. Counting Relays

Complex automatization of reversing and three-high rolling mills involves counting the passes, and after each or after several passes the counter must transmit orders to the individual mechanisms, making or breaking contacts in appropriate electric circuits. Counting relays consisting of a set of standard relays become very cumbersome at 10-15 and more passes per minute, require much apparatus, and are impracticable.

For automatic equipment of reversing and three-high rolling mills with a large number of passes, the Central Automatics Laboratory has designed counting step-relays for 6-12-18-24 passes with three interlocking circuits at each position.

3. Metal /Billet/ Position Indicators

For all types of mills, both with complex automatization and with automatic control of individual units, metal position indicators are indispensable elements of the circuit. Photo-relays, mechanical indicators (flag switches, compression rollers, etc.) and pressure relays may be used for this purpose.

Photo-relays of the metallurgical type are undergoing final development at present at the Central Automatics Laboratory, and one of the plants of the Ministry of the Electrical Industry. The photo-relay designed by the Central Automatics Laboratory has two cascades with a large range of sensitivity variation increased by means of an optical system. The first cascade is enclosed in a cast casing with water cooling, and can be located in the immediate neighborhood of the metal. The output relay of the second cascade is a powerful, multicontact relay of the RE-100 type, which is extensively used in systems for automatic control of electric drives. The presence of two cascades enables the photocell head to be located at any distance possible in practice from the amplifier of the second cascade, the connection being made by an ordinary conductor.

However, experience shows that photo-relays operate reliably only on mills rolling large sections (of the order of 50 by 50 [centimeters] and over). For smaller sections, the sensitivity of the photo-relay must be increased considerably, which results in false closing of the relay due to extraneous light. Therefore, it is undersirable to use photo-relays for small sections, and mechanical indicators are more reliable in these cases. It is regrettable that the industry is not yet producing mechanical indicators for this purpose; shop-made models are in most cases neither durable nor reliable.

It is also undesirable to use photo-relays to indicate the presence of metal in the mill rollers, since two sets of relays (before and after the stand) would be required, while a photo-relay installed directly on the stand would operate under severe conditions (water spray, scale throwing, etc.). It is also very undesirable to install mechanical indicators near the stand, since they limit accessibility, hinder the rolling operations and repairs, and can be easily damaged if the metal jams in the stand.

Pressure relays, reacting to roller pressure or to deformation of the framework during rolling, are more convenient and reliable for determining the presence of metal in the rollers. The Central Automatics Laboratory has also designed an indicator of this type. The principle of its operation is as follows. A rod is rigidly secured to the frame by one end, and its other end rests on the armature of an induction transmitting element which is rigidly secured in the upper part of the frame. When the frame is deformed under pressure as the metal passes between the rollers, the rod is displaced a few tens of microns with respect to the induction element. This slight displacement of rod and armature causes a different voltage at the coils of the element, which acts on an electronic amplifier actuating the contacts of a Type RE-100 relay.

Thus, for efficient realization of complex automatization systems there is a need for all three types of position indicators.

Rapid development of satisfactory models of the special devices mentioned and their industrial production is a necessary condition for the wide introduction of complex automatization of rolling mills. In addition, new requirements must be met regarding strict observance of technological conditions and sometimes of the construction of the mill itself. [An example is presented, with the use of simple equations, to show that for a semicontinuous rolling mill it is essential that the velocity of the billet as it leaves the first stand is the same as its velocity on entering the second stand, and this velocity should also correspond to the velocity of the roller bed. Otherwise, it would be necessary to severely regulate the length of the billets.]

A serious mistake in complex automatization of existing rolling mills may be the underestimation of the part played by roller technicians and mechanics. Operating experience at the Magnitogorsk Combine showed that technicians and mechanics can be of great help in this matter. For example, in adjusting the automatic equipment on Mill 300, No 3, it turned out that the speed of the metal in Stand VIII, as a result of which "leakage" of the metal occurred on the skew rollers before Stand IX. It was not possible to increase the relative speed of the rollers of Stand IX, as both stands had a common drive motor. The technicians and mechanics solved this problem by increasing the diameter of the end rollers of Stand IX, and changing the calibration, thereby increasing the speed of the metal in Stand IX.

The role of designers in complex automatization of new mills under construction is even more important. If, when new mills are designed, account is taken of the requirements of automatic control with respect to choice of metal (billet) speeds in all phases of the mills, and if mechanical metal position indicators are efficiently planned and disposed and made as fixtures, the task of complex automatization will be considerably simplified.

In 1949, enterprises of the "Energometallurgprom" Trust, under the leadership of the Central Automatics Laboratory, carried out work on the automatization of mills of the Chusovoy Plant, Magnitogorsk Metallurgical Plant, the Plant imeni Dzerzhinskiy, and others.

Automatization of Other Plants

Automatization and automatic interlocking of individual components are being introduced at various coke and coal-tar chemical plants (Zaporozh'ye, Kirvoy Rog, N. Tagil, and others) in the form of automatic coke slaking and automatic sulfate separation.

A pumping station for removal of water from the Turinsk Mine has been put on automatic control since the beginning of 1949. Only one attendant is now required, and the resulting increase in efficiency has permitted removing one pump from service. Other pumps of this mine will also be reconverted.

There is a need for further and more extensive development of experimental and research work on automatic control of metallurgical units, priority being given to processes in nonferrous metallurgy and in the coke and coal-tar chemical industry and refractory industry.

Increasing Operating Rate of Electric Drives

In addition to complex automatization, considerable importance is also to be attached to partial automatization of individual units and mechanisms, the introduction of better systems of automatic control and regulation, increasing the operating rate of electric drives and modernization and improvement of the operational characteristics of electrical equipment. Much can and should be done in this field.

In the case of the flywheel drive, the problem of increasing its work cycle can be solved in many cases by using suitably adjusted and chosen automatic slip regulators. Operational experience on many mills shows that the actual loads and their character differ considerably from those taken when designing the electrical equipment. Therefore, the parameters of the rotor circuit in many cases are far from ideal; this reduces the output of the mill and results in additional losses of electric power.

To solve the concrete problems of the selection of optimum parameters and the setting of slip regulators, it is necessary to investigate the operating conditions of the drive, linking this investigation with the technology of metal rolling on the mill in question. The criterion for selecting the optimum parameters of the regulating circuit is either the magnitude of the current peaks or the temperature rise in the windings of the drive motor. Therefore, the appraisal and possible improvement of the work of a flywheel drive can be based on simple observation of the temperature of the motor and current kicks in the power line.

By establishing optimum operating conditions for induction motor drives and reducing the slip at many rolling mills of the Serov, Ufaleysk and Chelyabinsk Metallurgical Plants, the average rolling speed was raised and over one million kw-hr of power were saved annually.

In the case of the regulated, nonreversible dc drive, intensifying the work cycle requires a rigid characteristic obtainable by using an automatic speed regulator. The use of such a regulator enables the drop in speed of the drive motor under load to be reduced practically to zero and hence will permit increasing the rolling speed by 4-5% with a corresponding increase in the mill output.

For continuous and semicontinuous mills, automatic speed regulation, in addition to increasing output, helps in reducing rejects and increasing the yield of first-class parts. In this case, the automatic speed regulator should not only compensate for the drop in speed under load but maintain a definite speed ratio between separate stands under individual drives.

For reversing mills, the work of the electric drive can be increased not only by maintaining the maximum given speed, but by increasing the acceleration and deceleration rates in the transitional periods. This is especially important for mills with a small rolling length, in which the motor does not have time to attain its maximum speed.

However, increasing the acceleration and deceleration rates is limited by the maximum permissible current of the motor. Therefore, the chief aim of the automatic drive control circuit is to obtain optimum starting and braking characteristics, corresponding to the most complete utilization of the drive motor. For example, most reversing mills have a sharp drop in acceleration rate when changing from the basic to the maximum speed. This drop in acceleration, which is quite uncalled for by the operating conditions of the motor, makes it impossible to utilize the maximum speed of the motor, reduces the mean rolling speed, and decreases the productivity of the mill.

The braking conditions automatically transmitted by the control circuit are also not ideal in many cases. Obtaining the necessary (sufficiently low) speed of metal ejection from the rollers, together with the highest possible rolling speed before braking begins, requires forced deceleration of the motor at high speeds. Most rolling mill circuits do not satisfy these conditions, since their braking is over-protracted. This reduces the rolling speed, and in some passes increases the intervals between work cycles.

Many reversing mills with a small rolling length do not satisfy the requirements of atuomatic control since they operate only within the limits of the basic speed. The control circuits may be improved by using new methods of "forced" acceleration and deceleration, and automatic regulation of speed and braking processes, thereby achieving fuller utilization of the drive motor and decreasing the rolling time.

Modernization of the control system at a blooming mill enabled the roll drive motor acceleration to be increased 1.5 times and the braking time decreased by 40%, without increasing the peak currents.

Decreasing the intervals between work cycles of a reversing mill, which is extremely important for increasing output, is possible through more effective operation of the electric motor driving the auxiliary mechanisms (compression apparatus, roller beds, etc). This can be achieved by using the more flexible and improved Leonard control system with electric machine control. The use of such modern control systems not only decreases the intervals between work cycles but also results in a considerable saving in electric power, while at the same time decreasing the wear on the mechanisms.

However, in spite of the many achievements in the field of automatic control and regulation, the existing experience has not been disseminated as widely as it should. Insufficient work is being done on automatic control of such high-output and power-consuming enterprises as tube rolling and wire drawing mills. Little attention is being paid to providing standard and special equipment for plants reconverting to automatic control.

The First All-Union Conference of Power Engineers of the Metallurgical Industry drew up a concrete program of further work to be carried out on the automatization of technological processes in the metallurgical industry. The conference also pointed out the advisability of convening in 1950 a special conference of workers of the metallugical industries on problems of automatic control of thermal and technological processes, with the participation of cognizant technologists.

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